

“*Solen rosaceus*”—Three Species

by

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Abstract. The small jackknife clams living on the coast of southern California, the outer coast of Baja California, and in the Gulf of California, and known as “*Solen rosaceus* Carpenter, 1864,” belong to three different species: the allopatric species pair *S. (Ensisolen) rosaceus* Carpenter, 1864, from southern California, and *S. (E.) gemmelli* sp. nov. from the upper Gulf of California (San Felipe area), and the variable and widespread *S. (E.) rostriformis* Dunker, 1862, from southern California to La Paz. The subgenus *Ensisolen* Habe, 1977, is redefined. Neotypes of *Solen rosaceus* Carpenter, 1864, and *Solen lappeanus* Dunker, 1871, are designated.

INTRODUCTION

During preparative work for a revision of the western American Solenidae, I examined over 150 specimens of the small jackknife clams commonly arranged in collections and published in identification books and faunal lists under the name “*Solen rosaceus* Carpenter, 1864.” In spite of many citations, illustrations of these small bivalves are rather scarce. For example, the clam was not figured in such classic works as KEEP (1887, 1904), GRANT & GALE (1931), OLDROYD (1925), KEEP & BAILY (1935), and ABBOTT (1954), and also not in some of the smaller and more general field guides, such as ABBOTT (1968); the figures in KEEN (1958, 1971), MCLEAN (1969), and POHLO (1963) are not accurate.

There are, in fact, three species involved, which are quite close but differ in several constant characters. One species is described as new; the other two are redescribed and their taxonomy discussed. All belong to the subgenus *Ensisolen* Habe, 1977, which is redefined herein.

Abbreviations used in the text: AMNH—The American Museum of Natural History, New York; BMNH—British Museum (Natural History) (now “The Natural History Museum”), London, Great Britain; CAS—California Academy of Sciences, San Francisco; LACM—Los Angeles County Museum of Natural History, Los Angeles; MCZ—Museum of Comparative Zoology at Harvard University, Cambridge, Massachusetts; MNHN—Muséum National d'Histoire Naturelle, Paris, France; SDNHM—San Diego Natural History Museum, San Diego; UCB—University of California, Berkeley; USNM—National Museum of Natural History, Smithsonian Institution, Washington, D.C.; ZIM—Zoologisches Institut

und Museum der Universität Hamburg, Hamburg, Germany; ZMB—Zoologisches Museum der Humboldt-Universität Berlin, Berlin, Germany.

TAXONOMY

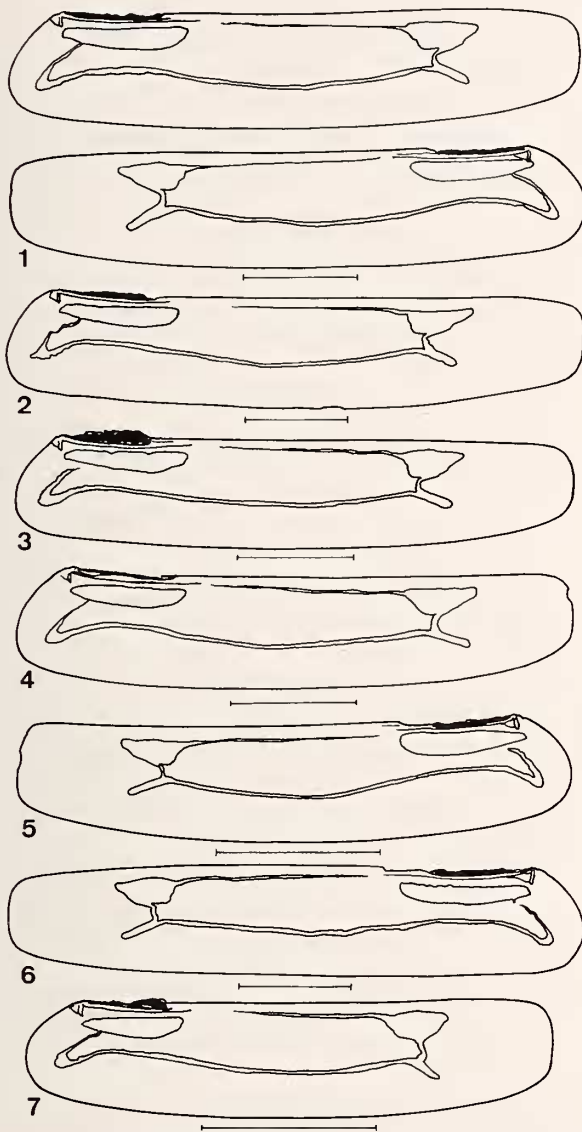
Genus *Solen* Linné, 1758

Solen LINNÉ, 1758:672.

Type species: *Solen vagina* Linné, 1758, by subsequent designation, Schumacher, 1817, central Indo-Pacific (see Figure 62 herein).

Approximately 65 Recent species, worldwide, mostly tropical and warm-temperate.

Shells small to very large, thin and fragile to solid, in shape variable but in general outline somewhat rectangular, from extremely long and narrow to rather short. Dorsal and ventral margin straight and parallel, straight and very slightly tapering, or valves more or less curved with convex ventral margin and dorsal margin concave, straight, or convex. Shells gaping at both ends. Anterior and posterior margin truncated or rounded to semicircular; truncated margins vertical or positively or negatively oblique. Beaks terminal, in species with semicircular anterior margin appearing slightly subterminal. Hinge and ligamental area straight or slightly bent dorsally. Exterior with or without a more or less pronounced furrow parallel to the anterior margin or with a slight depression only. Anterior adductor scar long-oval to very long and slender. Posterior adductor scar oval to triangular, situated above the posterior pallial line and united with the dorsal limb of the pallial sinus or situated in front of the posterior pallial line and separated from the pallial sinus. Pallial



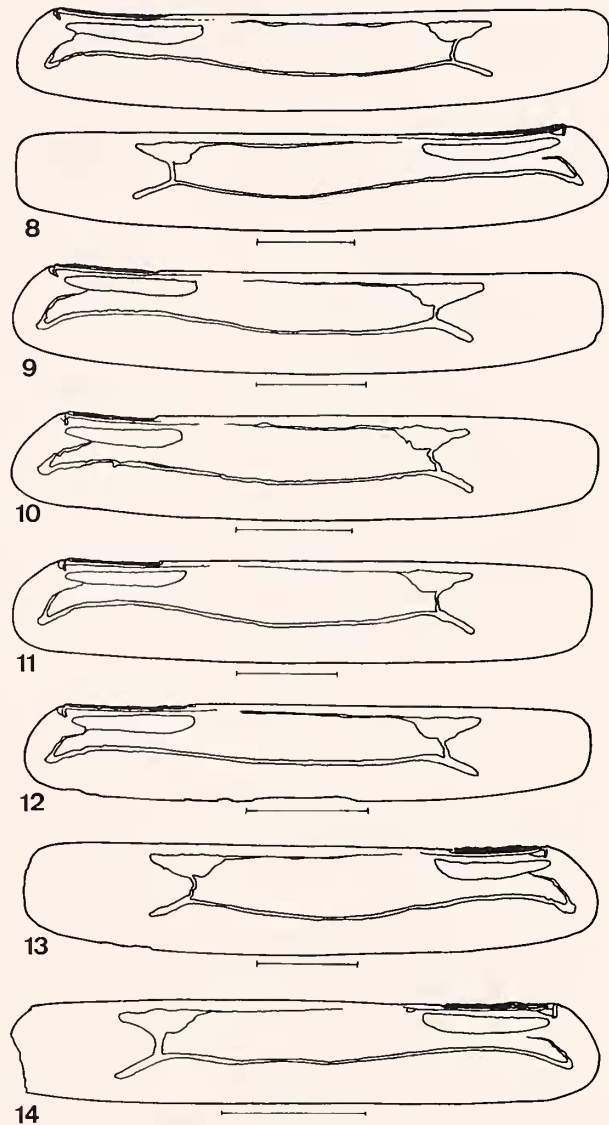
Explanation of Figures 1 to 7

Figures 1–7. *Solen rosaceus* Carpenter, all from California. Scale = 10 mm. Figure 1. San Pedro, Los Angeles (no data), neotype MNHN. Figure 2. San Diego (no data), AMNH 26307 (figured specimen in EMERSON, 1981:pl. 121, fig. 9). Figure 3. San Pedro, *leg.* E. P. Chace, MCZ 51594. Figure 4. San Pedro, *leg.* H. N. Lowe, 13 December 1924, MNHN, *ex* Staadt coll. Figure 5. San Diego, AMNH 26317, *ex* Oldroyd coll. Figure 6. San Pedro (no data), MNHN. Figure 7. Anaheim Landing, *leg.* E. P. Chace, MCZ 67379.

sinus short to very short, triangular, trapezoid or nearly square. Hinge with one cardinal in each valve, no laterals. Periostracum thin, in fully grown specimens of larger species rather thick and strong.

Subgenus *Ensisolen* Habe, 1977

Ensisolen HABE, 1977:228 [in Japanese].



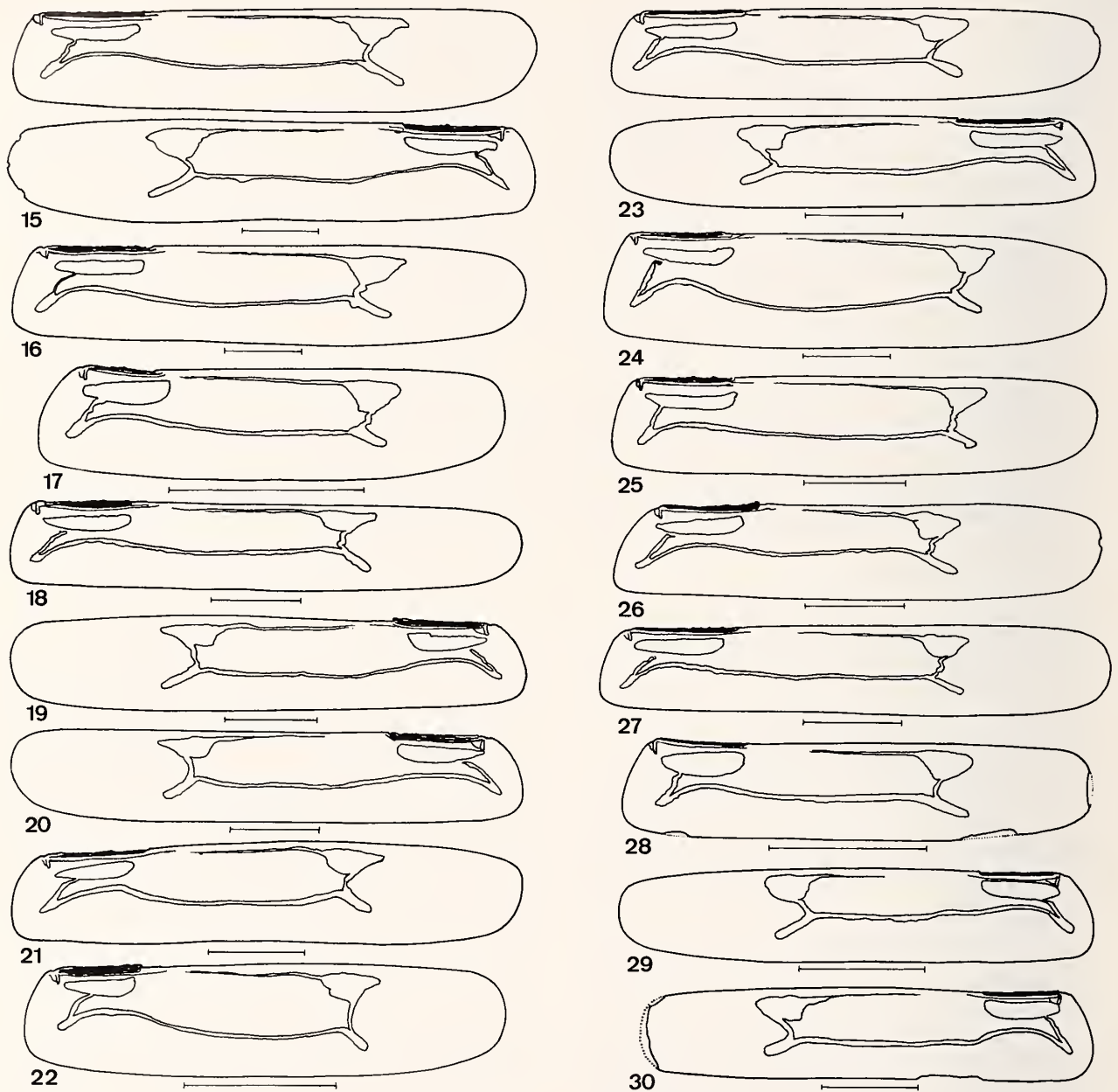
Explanation of Figures 8 to 14

Figures 8–14. *Solen gemmelli* Cosel, sp. nov., all from the San Felipe area, Baja California, Mexico. Scale = 10 mm. Figure 8. San Felipe, between Playa Alicia and El Paraiso, on sand bars at low tide, *leg.* Gemmell, holotype SDNHM. Figures 9–13. Same locality as in Figure 8, paratypes SDNHM. Figure 14. 32 km S of San Felipe, intertidally, *leg.* F. B. Howard, April 1957, LACM 104778, *ex* Kanakoff coll.

Type species: *Solen krusensterni* Schrenck, 1867, by original designation. Northern Japan, northward to Siberia, Ochotsk Sea (see Figure 60 herein).

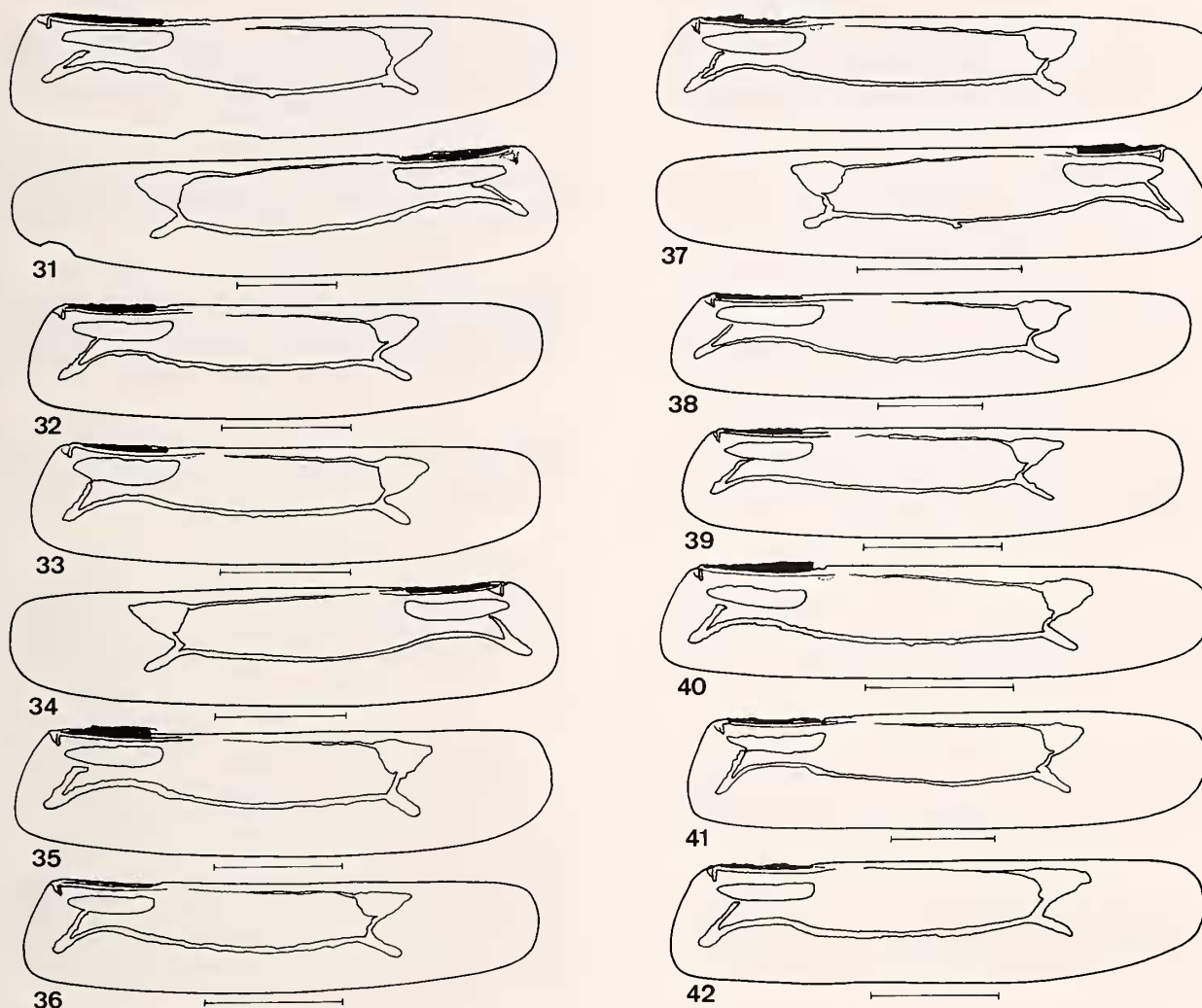
Fourteen to sixteen species, northwestern Pacific, eastern Pacific, western Atlantic.

Shells small to medium-sized, elongate to very elongate, and variable in length–width ratio, straight to somewhat curved, with general aspect like a short *Ensis*. Anterior margin rounded-truncate to nearly semicircular, posterior



Explanation of Figures 15 to 30

Figures 15-30. *Solen rostriformis* Dunker, "San Diego," "San Felipe," and "Mazatlan" forms. Scale = 10 mm. Figure 15. Santo Domingo, outer coast of Baja California, Mexico, leg. C. R. Orcutt, SDNHM 15442. Neotype of *Solen lappeanus* Dunker, 1871. Figure 16. Same locality as in Figure 15, SDNHM 15442. Figure 17. Bahia Concepcion, 1.6 km S of Punta Santo Domingo, AMNH 78609. Juvenile with shorter and broader shell. Figure 18. Upper Newport Bay, Orange Co., California, LACM 104777. Figure 19. Santa Barbara, California, leg. Forrer, ZMB, ex Dunker coll. Figure 20. Morro Bay, California, leg. M. & E. Caruthers, 1937, ZIM. Figure 21. San Diego Bay, California, MCZ 140200. Figure 22. San Diego Bay, California, 16-20 m, leg. C. A. Kofoid & W. J. Raymond, 13 July 1901, CAS IZ039968. Figure 23. 32 km S of San Felipe, Baja California, Mexico, leg. F. B. Howard, April 1957, LACM 104778. Figure 24. San Felipe, Baja California, leg. H. N. Lowe, 1933, SDNHM 22576. Figure 25. San Felipe Bay, Baja California, between Playa Alicia and Pete's Camp, sandbars at edge of low tide, leg. Gemmell, 1964-1975, SDNHM 90140. Figure 26. 40 km S of San Felipe, Baja California, leg. E. P. Chace, March 1957, MCZ 215041. Figure 27. Same locality as in Figure 23. Figures 28-30. Mazatlan, Sinaloa, Mexico, on beach, leg. L. G. Hertlein, 8 December 1932, CAS IZ039969.



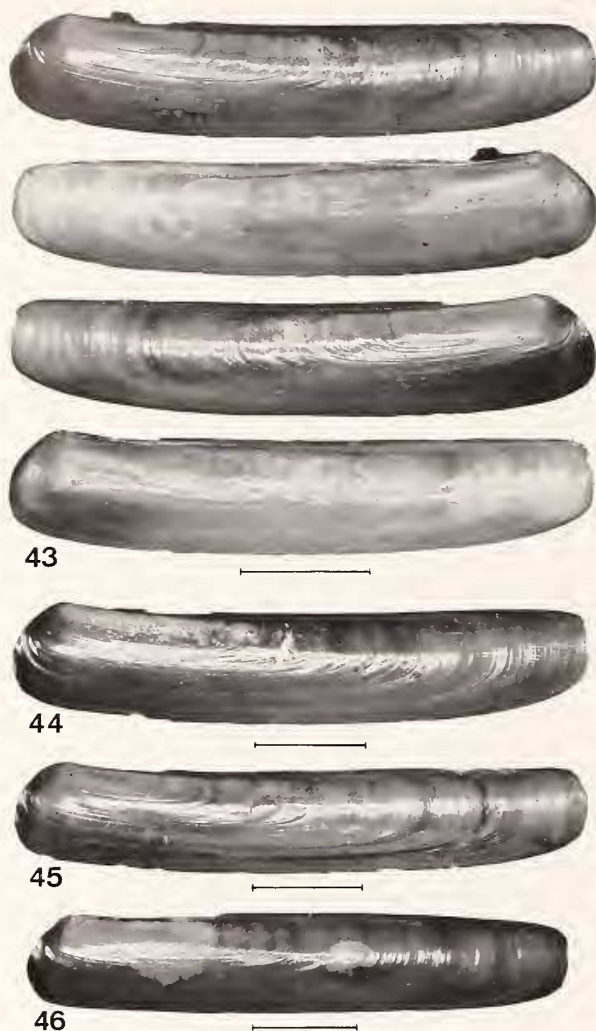
Explanation of Figures 31 to 42

Figures 31–42. *Solen rostriformis* Dunker, southern “La Paz” form. Scale = 10 mm. Figure 31. Holotype BMNH 19771, no locality. Figures 32–35. La Paz, Baja California, Mexico, SDNHM 71460. Figure 36. El Magote, Puerto de La Paz, Baja California, Mexico, 24°10'N, 112°W, intertidal to 2.5 m, *leg.* McLean *et al.*, 11 April 1966, LACM 66-29. Figures 37, 38. Bahia Magdalena, Baja California Sur (outer coast), intertidal sand flat, 0.8 km S of pier at Puerto San Carlos (24°47.4'N, 112°6.3'W), *leg.* C. Swift, 3 November 1971, LACM 71-186. Figure 39. Estero de Punta Banda, outer coast of Baja California (31°46.6'N, 116°37.3'W), *leg.* McLean, 20 December 1964, LACM 64-33. Figures 40, 41. Bahia Cholla, Puerto Penasco, Sonora, Mexico, AMNH 178035. Figure 42. Bahia Cholla, *leg.* R. B. Beck, MNHN, *ex* Staadt coll.

margin truncate, with rounded corners to well rounded or nearly semicircular. Dorsal margin somewhat concave to slightly convex, ventral margin always slightly to markedly convex. Posterior third or fourth of the valve more or less tapering. Hinge and ligamental area slightly bent dorsally. No sharp furrow parallel to the anterior margin, but sometimes with a very shallow, more or less broad depression. Posterior adductor scar always above the pallial sinus and united with its dorsal limb.

The short diagnosis by HABE (1977) gives as the distinguishing feature for *Ensisolen* only the anterior of the

shell, which is slightly curved and prolonged towards the anterior; in contrast, *Solen* has a truncate anterior. Further differences between *Ensisolen* and all other *Solen* (at this time maintained under this genus without other subgenera, although a subdivision would be necessary) are the situation of the posterior adductor scar above the pallial sinus and not in front of it, the more or less ensiform outline, and the lack of a deep and pronounced furrow along and parallel to the anterior margin. The anterior margin is indeed never straight and sharply truncate as in several other *Solen* (see Figures 62 and 63; for more examples,



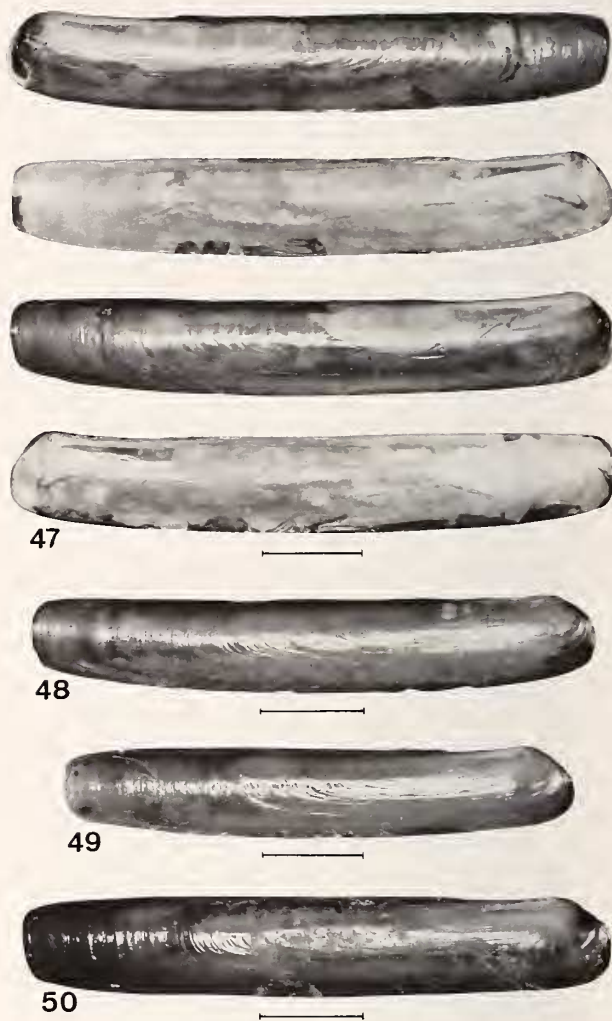
Explanation of Figures 43 to 46

Figures 43-46. *Solen rosaceus* Carpenter. Scale = 10 mm. Figure 43. Neotype MNHN, San Pedro, California, *leg.* H. N. Lowe, 23 December 1924 (*ex* Staat coll.). Interior and exterior of both valves. Figures 44, 45. Terminal Island, Los Angeles, California, *leg.* W. H. Eshnaur, 28 July 1928, MNHN, *ex* Staat coll. Exterior of two left valves. Figure 46. San Diego, California, AMNH 26317, *ex* Oldroyd coll. Exterior of a left valve.

see COSEL, 1989:195, 196, 198) but at least somewhat convex. In *Ensisolen*, the anterior and posterior corners are always more or less rounded (which makes, together with the often curved shell, the "ensiform" outline). The dorsal and ventral margins are never strictly parallel from end to end; the posterior taper is always more or less marked.

Solen (Ensisolen) rosaceus Carpenter, 1864

S. sicarius var. *rosaceus* CARPENTER, 1864:536, 638 (reprinted 1872:22, 124); CARPENTER, 1865:177 (reprinted 1872: 279).



Explanation of Figures 47 to 50

Figures 47-50. *Solen gemmelli* sp. nov., all from the San Felipe area, Baja California, Mexico. Scale = 10 mm. Figure 47. Holotype, SDNHM 90139. San Felipe, between Playa Alicia and El Paraiso, on sandbars at low tide, *leg.* Gemmell. Interior and exterior of both valves. Figures 48-50. Three paratypes, SDNHM 90139, same locality. External views of right valves.

S. rosaceus: MORRIS, 1952 (1960):55, pl. 15, fig. 4; MORRIS, 1966:39, pl. 23, fig. 2; ABBOTT, 1974:495, no. 5634 (fig.); EMERSON, 1981:681, pl. 121, fig. 9.

Type material: The material on which Carpenter's description is based is indicated as coming from E. Jewett (CARPENTER, 1864:536, 1865:177) and J. G. Cooper (CARPENTER, 1865:177). The still present material of these collections is now in USNM, UCB, or the Redpath Museum, McGill University. However, PALMER (1958) was unable to locate the type material of *Solen rosaceus* in one of these institutions and also not in BMNH (as erroneously stated by OLDROYD, 1925) (PALMER, 1958:25, 115); the material is apparently lost. For nomenclatural stability, a



Explanation of Figures 51 to 59

Figures 51-59. *Solen rostriformis* Dunker. Scale = 10 mm. Figure 51. "San Diego" form. Santo Domingo, outer coast of Baja California, Mexico, leg. C. R. Orcutt, SDNHM 15442. Neotype of *Solen lappeanus* Dunker, 1871. Interior and exterior of both valves. Figure 52. Second specimen of same lot as in Figure 51. Exterior of left valve. Figure 53. "San Diego" form. San Felipe Bay, Baja California, between Playa Alicia and Pete's Camp, sandbars at edge of low tide, leg. Gemmell, 1964-1975, SDNHM 90140. Exterior of left valve, interior of right valve. Figure 54. "San Diego" form. Newport Bay, California, MCZ 63501, ex E. P. Chace coll. Interior and exterior of left valve. Figure 55. Second specimen of same lot as in Figure 54. Interior and exterior of right valve. Figure 56. "San Diego" form. San Pedro, California, leg. A. N. Lowe, December 1924, MNHN, ex Staat coll. Interior and exterior of right valve. Figure 57. "La Paz" form. Holotype of *Solen rostriformis* Dunker, 1862. BMNH 19771. Interior and exterior of both valves. Figure 58. "La Paz" form. La Paz, Baja California Sur, Mexico, SDNHM 71460. Exterior of both valves, interior of left valve. Figure 59. Second specimen of same lot as in Figure 58. Exterior of left valve.

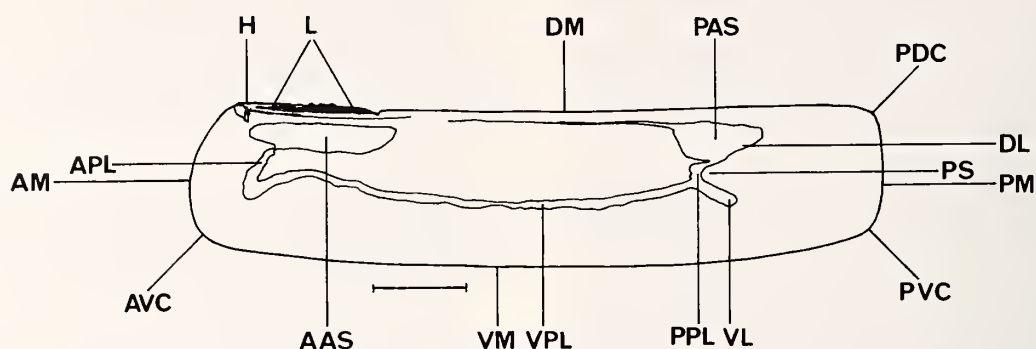


Figure 60

Diagram of *Solen krusensterni* Schrenck (type species of *Ensisolen*). Sukhodol Bight, Ussuri Bay, USSR, on beach, leg. K. A. Lutaenko, 2 April 1989, MNHN. Explanation of shell characters: AAS, anterior adductor scar; AM, anterior margin; APL, anterior pallial line; AVC, anteroventral corner; DL, dorsal limb of pallial sinus (here united with the posterior adductor scar); DM, dorsal margin; H, hinge tooth under the beak; L, ligament; PAS, posterior adductor scar; PDC, posterodorsal corner; PM, posterior margin; PPL, posterior pallial line; PS, pallial sinus; PVC, posteroventral corner; VL, ventral limb of pallial sinus; VM, ventral margin; VPL, ventral pallial line.

neotype is designated here: MNHN, San Pedro, leg. H. N. Lowe, 23 December 1924.

Type locality: "Santa Barbara (Jewett); San Pedro (Cooper)" (CARPENTER, 1865:177), here restricted to San Pedro, California (33°45'N, 118°19'W).

Description: Shell small, up to 57 mm long, elongate, somewhat variable in length-width ratio (4.7-5.5:1), thin and fragile. Dorsal margin straight to very faintly concave, rarely somewhat convex; ventral margin generally distinctly convex, often giving the valves as a whole a slightly curved appearance. Anterior margin well rounded and prominent; posterior third or fourth of the valves tapering, ventrally more than dorsally; posterior margin vertically truncate, with well-rounded corners. Broadest part of the valves in front of the posterior muscle scar. Hinge and ligamental area slightly bent upwards.

Anterior adductor scar elongate, by $\frac{1}{3}$ to $\frac{1}{6}$ longer than

the ligament. Posterior adductor scar above the pallial sinus and united with its dorsal limb. Pallial sinus short and rather narrow, with the innermost point usually in the middle or the lower part, occasionally in the upper part. Distance between innermost point of pallial sinus and posterior margin relative to the total shell length ("pallial sinus ratio"; for diagrams see Figure 60 and COSEL, 1989:204) 1:3.6-4.1. Exterior smooth and glossy, with fine, irregular growth lines.

Valves whitish, with several concentric pale brownish-red zones parallel to the growth lines. Periostracum light olive greenish. Interior light grayish white with the brownish-red zones showing through.

Animal not seen.

Selected measurements with length-width ratio:

57.3 × 10.5 mm Long Beach, SDMNH	5.5 : 1
56.7 × 10.5 mm San Diego, AMNH	5.4 : 1

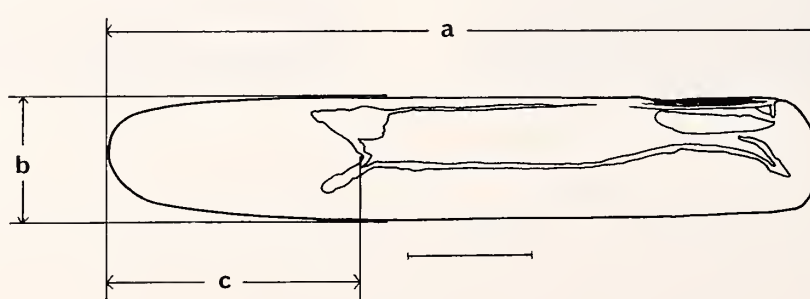
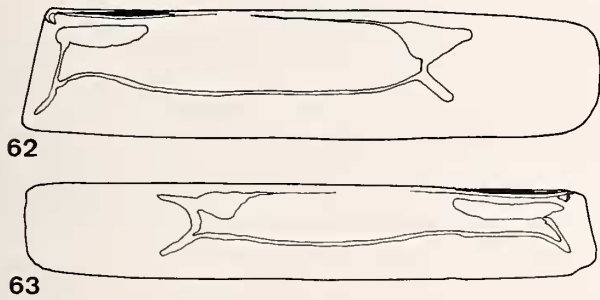


Figure 61

Diagram of *Solen rostriformis* Dunker. Upper Newport Bay, Orange Co., California, LACM 104777. Explanation of shell parameters: a = shell length; b = shell width; a:b = length-width ratio; c = distance from innermost point of the pallial sinus to the posterior margin; c:a = pallial sinus ratio (ratio of the distance between the innermost point of the pallial sinus and the posterior margin to total shell length).



Explanation of Figures 62 to 63

Figures 62 and 63. Examples of *Solen* not belonging to *Ensisolen*. Figure 62. *Solen vagina* Linné, 1758. Possible syntype, Linnean Society of London. Type species of the genus *Solen*. Note the sharply truncated anterior margin; an anterior furrow is absent; the posterior adductor scar is united with the dorsal limb of the pallial sinus. Figure 63. *Solen sloanii* Gray in Hanley, 1842. The inflexion at the anteroventral corner marks the deep anterior furrow; the posterior adductor scar is situated in front of the pallial sinus.

55.6 × 10.4 mm Long Beach, SDMNH	5.3 : 1
54.1 × 10.3 mm Long Beach, SDMNH	5.3 : 1
52.8 × 10.4 mm Long Beach, SDMNH	5.1 : 1
51.6 × 9.5 mm San Diego, AMNH	5.4 : 1
50.1 × 9.6 mm Long Beach, SDMNH	5.2 : 1
50.0 × 9.7 mm Long Beach, SDMNH	5.2 : 1
47.9 × 9.6 mm San Diego, AMNH	5.0 : 1

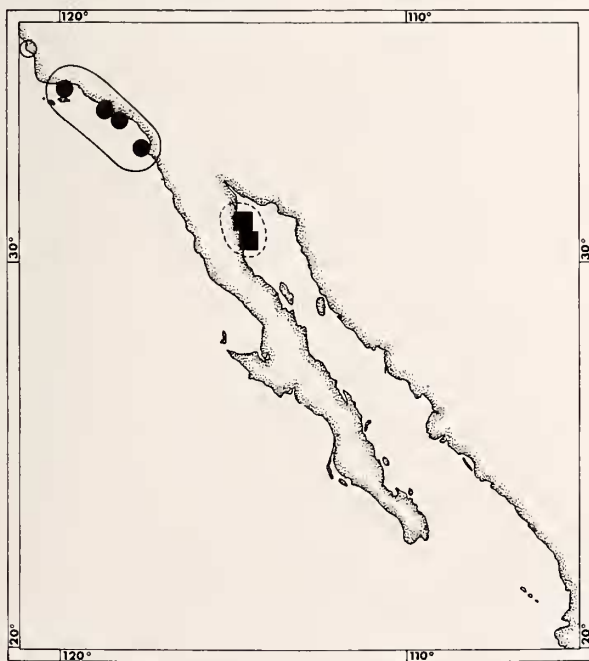


Figure 64

Distributions of *Solen rosaceus* (circles) and *Solen gemmelli* Cosel, sp. nov. (squares). The doubtful record from Morro Bay is marked by an empty circle.

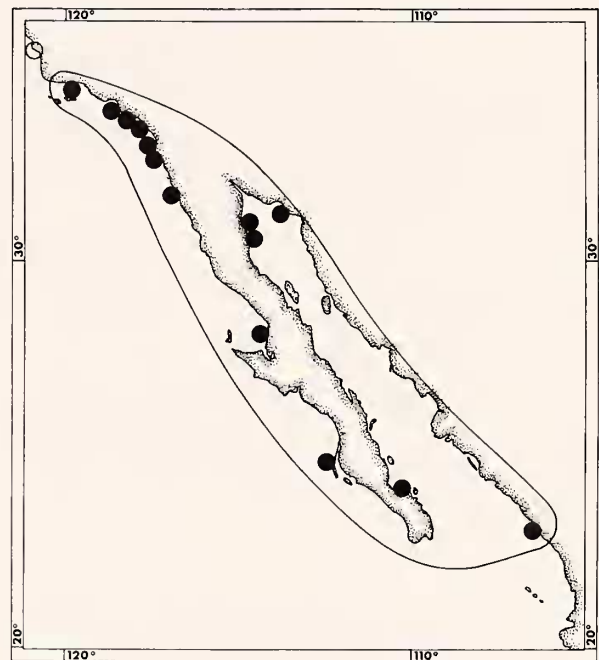


Figure 65

Distribution of *Solen rostriformis*. The doubtful record from Morro Bay is marked by an empty circle.

47.2 × 8.8 mm San Pedro, MCZ	5.4 : 1
44.8 × 8.8 mm San Diego, AMNH	5.1 : 1
44.7 × 9.6 mm San Pedro, MCZ	4.7 : 1
44.4 × 8.7 mm San Pedro (neotype)	5.1 : 1
44.0 × 8.8 mm San Diego, AMNH	5.0 : 1
44.0 × 8.4 mm San Diego, AMNH	5.3 : 1
43.8 × 9.2 mm San Pedro, MCZ	4.8 : 1
35.1 × 7.1 mm San Pedro, MCZ	4.9 : 1
30.0 × 6.0 mm San Pedro, MCZ	5.0 : 1
29.9 × 6.2 mm San Pedro, MCZ	4.8 : 1

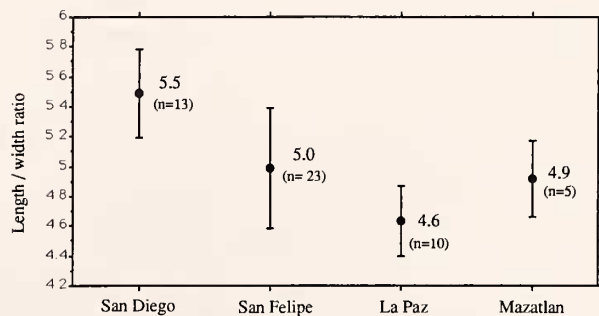


Figure 66

Length-width ratio of *Solen rostriformis* populations from California and the outer coast of northern Baja California ("San Diego"), the San Felipe area in the northern Baja Gulf of California ("San Felipe"), northern to southern Baja California ("La Paz"), and Mazatlan. Bars are 1 SD.

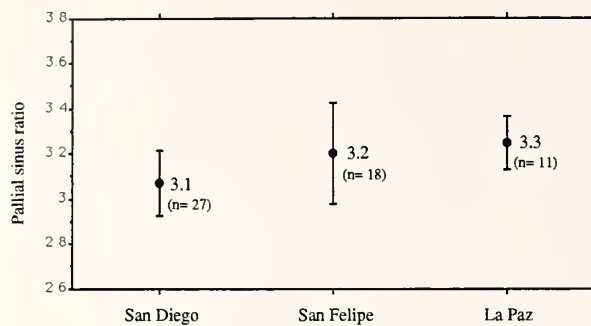


Figure 67

Pallial sinus ratio of *Solen rostriformis* populations from California and the outer coast of northern Baja California ("San Diego"), the San Felipe area in the northern Gulf of California ("San Felipe"), and northern to southern Baja California ("La Paz"). Bars are 1 SD.

Distribution: Restricted to a rather short strip on the California coast. Usually, Santa Barbara (34°N) is given as the northern limit; a mixed lot in ZIM containing both this species and *Solen rostriformis* is labelled "Morro Bay" (35°20'N), but this record needs confirmation. The species goes southward to San Diego (33°N).

Material examined: The neotype; USA, CALIFORNIA: Morro Bay, 1 shell, M. & E. Caruthers, 1937, ZIM; Long Beach, Los Angeles, 7 shells, SDMNH, ex H. N. Lowe coll.; Terminal Beach, Los Angeles, 1 shell, leg. Tremper, AMNH 206948; Terminal Island, Los Angeles, 4 shells, 5 valves, leg. Mrs. W. H. Eshnaur, 28 July 1928, MNHN, ex Staadt coll.; Anaheim Landing, San Pedro Bay, Los Angeles, 5 shells, leg. E. P. Chace, MCZ 67379; San Pedro, Los Angeles, 10 shells (no more details), MCZ 51594, ex E. P. Chace coll.; 5 shells (no more details), MNHN, ex Denis coll.; San Diego, 6 shells, AMNH 26317, ex I. S. Oldroyd coll., 1 shell, AMNH 26307 (specimen figured in EMERSON, 1981:pl. 121, fig. 9).

Biotope: In fine muddy sand in protected bays, from the lower intertidal zone to shallow water, apparently only locally common.

Remarks: This species is characterized by its typical pale brownish-red growth zones in combination with the normally slightly curved shell, the rounded anterior margin, and the rounded-truncated posterior margin (one of the studied specimens had a straight shell, Figure 5). The species closest to *Solen rosaceus* in outline and arrangements of muscle scars and mantle line is *S. tairona* Cosel, 1985, from the Colombian Caribbean coast; however, this South American species is a bit more slender, much smaller, thinner, and virtually translucent. The other close Atlantic species, *S. viridis* Say, 1821, from the U.S. east coast (Rhode Island to Texas) is translucent white (occasionally with a few rose growth lines in southern specimens) and has a pale yellowish green periostracum. The only eastern Pa-

cific species resembling *S. rosaceus* is *S. gemmelli* sp. nov. (see description below). *Solen sicarius*, of which *S. rosaceus* was originally considered a "variety" by Carpenter, is much larger, heavier, and somewhat shorter and broader, with a less rounded posterior margin. This more northern species has a much wider range, from the extreme southeast of Alaska (56°N) (BERNARD, 1983) to north of San Diego (33°N, rare) (BERNARD, 1983); *S. rosaceus* overlaps with it in the greater part of its range.

The type material of *Solen rosaceus* has never been figured. From the brief descriptions ("*Solen* ?var. *rosaceus*. Straight, narrower, longer, smaller; glossy, rosy"—CARPENTER, 1864:638; "*Solen* (?*sicarius*, var.) *rosaceus*. S. testa *S. sicario* simili, sed minore; multo angustiore, elongata, recta, extus et intus rosacea; epidermide tenui, valde nitente."—CARPENTER, 1865:177), it is not clear which of the two sympatrically occurring species Carpenter really had before him. From the "similarity" to *S. sicarius* and the "rosy" coloration on the interior and exterior, and in spite of the citation "straight," one could assume that the rather range-restricted California species treated above was concerned (although it is mostly slightly curved), but it is not completely sure. However, the final reason for selecting the neotype of *Solen rosaceus* from this species is nomenclatural: using the name *rosaceus* for this species avoids the introduction of another new name.

Solen (Ensisolen) gemmelli Cosel, sp. nov.

(Figures 8–14, 47–50, 68, 69)

Solen new species A: GEMMELL, MYERS & HERTZ, 1987:57.

Type material: Holotype SDNHM 90139, San Felipe, Golfo de California, Mexico, between Playa Alicia and El Paraiso, on sandbars at low tide mark, leg. Gemmell, between 1965 and 1976. Paratypes: Pete's Camp to Playa Alicia, a coastline of about 50 km, stretching N and S of Bahia San Felipe, 5 specimens (3 partly broken), 3 valves, SDNHM 90139 [new number for paratypes].

Type locality: San Felipe, Golfo de California, Mexico (31°03'N, 114°52'W).

Description: Shell rather small, up to 63 mm long, thin and translucent, very elongate, somewhat variable in outline, slightly curved to occasionally straight, with length-width ratio 5.3–6.3:1. Anterior margin obliquely rounded-truncate, with well-rounded anteroventral corner. Posterior margin vertically truncate, slightly convex, with well-rounded dorsal and ventral corners. Dorsal margin somewhat concave to straight, rarely somewhat convex in its posterior part; ventral margin mostly slightly convex. Hinge and ligamental area faintly to markedly bent upwards.

Anterior adductor scar long and narrow, about ¼ to ½ its length longer than the ligament. Posterior adductor scar united with the pallial sinus and stretching for half of its length above it. Pallial sinus triangular to trapezoid, with

the innermost point mostly in the upper part. Distance between that innermost point and the posterior margin relative to the total shell length 1:3.4–4.0.

Exterior smooth, with faint growth lines and coarser growth stages. Valves entirely white and lacking any coloration, periostracum light yellowish green.

Live or wet preserved animals not seen.

Selected measurements with length–width ratio:

63.0 × 11.1 mm San Felipe (paratype)	5.7 : 1
60.0 × 9.5 mm San Felipe (holotype)	6.3 : 1
57.3 × 9.6 mm San Felipe (paratype)	6.0 : 1
56.5 × 10.6 mm San Felipe (paratype)	5.3 : 1
53.4 × 8.8 mm San Felipe (paratype)	6.1 : 1
49.6 × 8.6 mm San Felipe (paratype)	5.8 : 1
42.2 × 7.5 mm San Felipe (paratype)	6.2 : 1
36.8 × 7.0 mm San Felipe (paratype)	5.3 : 1
26.0 × 4.8 mm San Felipe (paratype)	5.4 : 1

Distribution: At present only known from the San Felipe area, Gulf of California, Pacific coast of Mexico.

Material examined: The type material; MEXICO: 32 km S of San Felipe, Baja California, intertidal, 1 valve, *leg.* Faye B. Howard, April 1957, LACM 104778, *ex* Kana-koff coll.

Etymology: The species is dedicated to Joyce Gemmell, who assembled an extensive marine mollusk collection from the San Felipe area between 1964 and 1975 (GEMMELL *et al.*, 1987) and collected the species here described.

Biotope: In fine sand, at lower intertidal zone and low water mark.

Remarks: This new species is in outline very close to *Solen rosaceus* and *S. tairona*; however, the most conspicuous features that distinguish it from *S. rosaceus* are the complete lack of color and its generally longer and much more slender shell. It is the most slender species of the *rosaceus* group, only *S. tairona* approximates it nearly (5.2:1 for *S. tairona* versus 5.3:1 for the “shortest” *S. (E.) gemmelli*). There are no substantial differences in the curvature of the margins and the muscle impressions; however, the anterior muscle scar and the ventral limb of the pallial sinus in *S. gemmelli* are more prolonged, corresponding to the longer shell. *Solen rostriformis* (see below), which occurs with *S. gemmelli* in the same habitat, is shorter and straight, with a rounded posterior margin, more truncate anterior margin, and a larger distance between the innermost point of pallial sinus and posterior margin.

The southernmost record of *Solen rosaceus* is San Diego, and no record of this species on the outer coast of Baja California is known to me. This leads to the assumption that *S. gemmelli* and *S. rosaceus* might be a pair of allopatric sibling species, the Caribbean and eastern Atlantic counterpart being *S. tairona* in the south and *S. viridis* in the north.

Solen (Ensisolen) rostriformis Dunker, 1862

Solen rostriformis DUNKER, 1862:421.

Solen lappeanus DUNKER, 1871:129–130, pl. 44, fig. 1.

Solen new species B: GEMMELL, MYERS & HERTZ, 1987:57.

S. rosaceus: WEYMOUTH, 1920:50; pl. 15, fig. 3; FITCH, 1953: 76, fig. 42; MCLEAN, 1969:88, fig. 3; HADERLIE & ABBOTT, 1980:385, pl. 124, fig. 15.62; REHDER, 1981: fig. 615, p. 673.

Type material: The holotype of *Solen rostriformis* is in BMNH (No. 19771). The type material of *S. lappeanus* has not been located, either in BMNH or in ZMB, and is apparently missing. For nomenclatural stability, a **neotype** is **designated here**: SDNHM 15442, Santo Domingo, Baja California, *leg.* C. R. Orcutt.

Type locality: *Solen rostriformis*: not given, here selected as La Paz, Baja California Sur, Mexico (24°10'N, 110°17'W). *S. lappeanus*: “Mare Antillarum,” here corrected to Santo Domingo, Baja California, Mexico (28°10'N, 114°08'W).

Description: Shell small to medium-sized, up to 70 mm long, thin and fragile (very large specimens rather solid), elongate, very variable in length–width ratio (4.6–6.0:1), outline and coloration. Dorsal margin straight to faintly convex; ventral margin straight, slightly convex or occasionally even slightly concave in the middle part. Anterior margin more or less obliquely truncated, with rounded ventral corner, posterior margin well-rounded to nearly semicircular. Posterior part weakly to markedly tapering from just in front of or behind the level of the posterior adductor scar. Broadest part of the valves in the middle or behind the middle but usually more or less in front of the posterior adductor scar. Hinge and ligamental area slightly bent dorsally.

Anterior adductor scar elongate, somewhat variable in length, slightly shorter or longer than the ligament. Posterior adductor scar above the pallial sinus and its posterior part united with the dorsal limb of the sinus. Pallial sinus short, with the innermost point mostly at the lower part. Distance between innermost point of the pallial sinus and posterior margin relative to the total shell length somewhat variable but always rather large: 1:2.7–3.6. Exterior with fine irregular growth lines and occasional coarser growth stages.

Valve color varies from entirely white, whitish with rosy hue especially between the anterior adductor scar and the ligament plate or around the scar, slightly brownish pink, uniform pale pink or white to pale pink with occasional more intensively colored growth zones. Periostracum greenish to light brownish green, in very large specimens turning to brown. Interior with same coloration as exterior.

Animal not seen.

Selected measurements with length–width ratio:

69.5 × 13.2 mm Sto. Domingo (neotype of <i>S. lappeanus</i>), SDNHM 15442	5.3 : 1
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68.0 × 13.0 mm	Sto. Domingo, Baja California, SDNHM 15442	5.2 : 1
64.5 × 10.8 mm	Upper Newport Bay, LACM 104777	6.0 : 1
64.4 × 10.7 mm	Upper Newport Bay, LACM 104777	6.0 : 1
63.7 × 11.6 mm	San Diego, MCZ 74369	5.5 : 1
59.8 × 10.6 mm	Santa Barbara, ZMB	5.6 : 1
58.9 × 11.2 mm	Upper Newport Bay, LACM 104777	5.3 : 1
58.4 × 11.6 mm	Bahia San Felipe, SDNHM 90140	5.0 : 1
57.5 × 11.0 mm	San Diego, AMNH 51594	5.2 : 1
56.9 × 12.3 mm	San Felipe, SDNHM 22576	4.6 : 1
55.7 × 10.1 mm	Santa Barbara, ZMB	5.5 : 1
55.5 × 11.8 mm	Holotype of <i>S. rostriformis</i> , BMNH	4.7 : 1
55.5 × 11.1 mm	San Diego, MCZ 140200	5.0 : 1
53.6 × 9.3 mm	40 km S of San Felipe, MCZ 215041	5.8 : 1
51.1 × 10.1 mm	40 km S of San Felipe, MCZ 215041	5.1 : 1
49.6 × 8.7 mm	Tierra del Fuego Isle, SDNHM 54947	5.7 : 1
49.2 × 9.6 mm	Puerto San Carlos, LACM 71-186	5.1 : 1
49.1 × 10.5 mm	Puerto Penasco, AMNH 178035	4.7 : 1
48.2 × 10.4 mm	Mazatlan, CAS 03969	4.6 : 1
46.7 × 8.8 mm	Newport Bay, MCZ 63501	5.3 : 1
46.0 × 8.7 mm	Mazatlan, CAS 03969	5.3 : 1
44.0 × 7.9 mm	Tierra del Fuego Isle, SDNHM 54947	5.6 : 1
42.0 × 9.0 mm	La Paz, SDNHM 71460	4.7 : 1
41.6 × 8.6 mm	La Paz, SDNHM 71460	4.8 : 1
36.7 × 7.5 mm	El Magote, La Paz, LACM 66-29	4.9 : 1
35.8 × 7.4 mm	Estero de Punta Banda, LACM 64-33	4.8 : 1

Distribution: Santa Barbara, California (34°N), southward to Mazatlan, Sinaloa, Mexico (23°N), and throughout the Gulf of California. As in *Solen rosaceus*, the mixed lot from Morro Bay in ZIM might suggest a range extension to the north, but that needs confirmation.

Material examined: USA, CALIFORNIA: Morro Bay, 1 shell, 1 valve, *leg.* M. Caruthers, 1937, ZIM; Santa Barbara, 2 shells, ZMB, *ex* Dunker coll.; Terminal Beach, Los Angeles, 3 valves, AMNH 206948, *ex* Tremper coll.; Terminal Island, Los Angeles, 1 valve, *leg.* Mrs. W. H. Eshnour, 28 July 1928, MNHN, *ex* Staadt coll.; Newport Bay, Orange Co., 3 shells, *leg.* T. Burch, AMNH 131917;

7 shells, *leg.* E. P. Chace, MCZ 63501; Upper Newport Bay, 7 shells, LACM 104777; San Diego Bay (no more details), 30 shells, MCZ 140200, *ex* Grand Rapids Public Museum; 3 shells, AMNH 51594, *ex* Constable coll.; 1 valve, AMNH 26917, *ex* Oldroyd coll.; San Diego Bay, 9–11 fm., 16 specimens, *leg.* Kofoid & Raymond, 13 July 1901, CAS 039968; San Diego (no more details), 4 shells, 1 valve, MCZ 74369, *ex* Hemphill coll.; 3 shells, MCZ 74370, *ex* Button coll.; 4 shells, MCZ 87121, *ex* Roper coll.; 1 shell, MNHN, *ex* Denis coll.; Tierra del Fuego Isle, Mission Bay, San Diego, 6 shells, *leg.* R. L. Morrison, 11 April 1969, SDNHM 54947; Chula Vista, near San Diego, 1 shell, *leg.* Reed, ZIM; California (no details), 2 × 1 shell, MNHN; MEXICO: Estero de Punta Banda, Baja California, 31°46.6'N, 116°37.3'W, intertidal sand and mudflats, 1 specimen, *leg.* McLean, 20 December 1964, LACM 64-33; Santo Domingo, Baja California, 2 shells, *leg.* C. R. Orcutt, SDNHM 15442, *ex* Baily coll.; Bahia Santa Inez, 1.6 km S of Sto. Domingo Pt., Baja California, 2 shells, *leg.* C. R. Orcutt, SDNHM 15442, *ex* Baily coll.; Bahia Santa Inez, 1.6 km S of Sto. Domingo Pt., Baja California, 1 shell, 1 valve, AMNH 78609; Puerto San Carlos, Bahia Magdalena, Baja California Sur, 24°47.4'N, 112°6.3'W, intertidal sand flat, 3 specimens, *leg.* C. Swift, 3 November 1971, LACM 71-186; La Paz, Baja California Sur (no more details), 5 shells, 2 valves SDNHM 71460; El Magote, La Paz Harbour, 24°10'N, 112°00'W, 1 specimen, *leg.* McLean *et al.*, 11 April 1966, LACM 66-29; 40 km S of San Felipe, Baja California, 7 shells, 1 valve, *leg.* E. P. Chace, March 1957, MCZ 215041; 32 km S of San Felipe, 21 shells, *leg.* F. B. Howard, April 1957, LACM 104778, *ex* Kanakoff coll.; Diggs Point, S of San Felipe, 4 shells, *leg.* E. C. Huffman, June 1934, LACM 104775; 3 shells, *leg.* Huffman, MNHN, *ex* Staadt coll.; San Felipe, in mud just below the surface, 2 specimens, *leg.* M. Rogers, 31 December 1955, LACM 104776; 6 shells, SDNHM 225760, *ex* Lowe coll.; 2 shells, AMNH *ex* Chace coll.; Bahia San Felipe, between Playa Alicia and Pete's Camp, sandbars at edge of low tide, 6 specimens, *leg.* Gemmell, between 1964 and 1975, SDNHM 90140; Bahia Cholla, Puerto Penasco, Sonora, 5 shells, February 1970, AMNH 178035; 1 shell, *leg.* Mrs. R. B. Beck, MNHN, *ex* Staadt coll.; Mazatlan, Sinaloa, *leg.* L. G. Hertlein, 7 valves, 1 fragment, 8 December 1932, CAS IZ039969.

Biotope: In fine sand and fine muddy sand from somewhat above low tide mark to shallow water (10 m).

Remarks: *Solen rostriformis* is distinguished from *S. rosaceus* and *S. gemmelli* by its broader and less curved or straight shell, with truncated anterior and rounded posterior margins, and its white to whitish pink coloration, often with deeper pink in the anterior adductor scar region.

This is an extremely variable species, which tends to develop more or less defined "forms" in the different parts of its distribution. Four are identified below.

Los Angeles and San Diego area (one isolated lot from Santo Domingo, Baja California) ("San Diego" form):

Shells up to about 70 mm long, dorsal margin straight or faintly convex, ventral margin straight or slightly convex, occasionally even somewhat concave; length-width ratio 5.2-5.7:1. Posterior part dorsally and ventrally only slightly tapering; broadest part of the valve mostly behind the middle, more or less near the posterior muscle scar. Distance from the innermost point of the pallial sinus to the posterior margin very large, always more than ¼ of shell length, in fully grown specimens to ½ of total shell length (see Table 1). Valves whitish to beige-whitish, anterodorsal often tinged with pale pink and occasionally with a few faint pinkish growth zones. Interior white, mostly with pinkish zone above the anterior adductor scar or a rosy hue around the scar. The two specimens from Santo Domingo are pale brownish rosy with a pink hue above the anterior adductor scar.

West and south coast of Baja California (Estero de Punta Banda, Bahia Magdalena, La Paz) ("Baja California" or "La Paz" form):

Shells to about 55 mm long, with the ventral margin convex over the whole length, dorsal margin straight, occasionally faintly convex but always less than ventral margin; length-width ratio 4.7-5.1:1. Posterior part mostly ventrally tapering from in front of the posterior muscle scar; broadest part of the valve in the middle or slightly before the middle, always in front of the posterior adductor scar. Distance between the innermost point of the pallial sinus and the posterior margin often slightly shorter than in the "San Diego" form (see Table 1). Valves entirely pale rosy or whitish with pink growth zones, rarely entirely white.

Northwestern part of the Gulf of California (San Felipe area) ("San Felipe" form):

Shells up to about 60 mm long, very similar to the San Diego population, but mostly somewhat shorter, with dorsal and ventral margin straight or slightly convex; length-width ratio 4.2-5.8:1. Posterior part slightly tapering dorsally and ventrally as in the San Diego specimens. Broadest part of the valves in the middle or behind the middle, slightly in front of the posterior muscle scar. Distance between the innermost point of the pallial sinus and the posterior margin generally shorter as in the San Diego specimens but occasionally as long (see Table 1). Valves entirely white, sometimes with a pale pinkish point near the beak and rarely with a more extended pinkish hue.

Mazatlan ("Mazatlan" form):

Shells apparently smaller than the more northern specimens (see measurements), dorsal and ventral margin faintly convex; length-width ratio 4.6-5.3:1. Posterior part dorsally and ventrally tapering from the posterior adductor scar onward. Broadest part of the valves just in front of the posterior adductor scar. Distance between the innermost point of the pallial sinus and the posterior margin

Table 1

Comparisons of the length-width ratio and the pallial sinus ratio (the ratio of the innermost point of the pallial sinus to total shell length) in the different morphs of *Solen rostriformis*.

Length-width ratio					
	Ratio	Mean	SD	SE	n
San Diego	5.2-5.7:1	5.485	0.297	0.082	13
San Felipe	4.2-5.8:1	4.983	0.398	0.083	24
La Paz	4.7-5.1:1	4.63	0.231	0.073	10
Mazatlan	4.6-5.3:1	4.92	0.259	0.116	5

Comparisons (* = significant at 95%)

	Mean diff.	Fisher PLSD	Scheffe F-test
San Diego vs. San Felipe	0.502	0.234*	6.188*
San Diego vs. La Paz	0.855	0.284*	12.205*
San Diego vs. Mazatlan	0.565	0.356*	3.404*
San Felipe vs. La Paz	0.353	0.256*	2.562
San Felipe vs. Mazatlan	0.063	0.333	0.048
La Paz vs. Mazatlan	-0.29	0.37	0.829

Pallial sinus ratio

	Ratio	Mean	SD	SE	n
San Diego	1:2.8-3.3	3.07	0.146	0.028	27
San Felipe	1:2.7-3.6	3.2	0.225	0.053	18
La Paz	1:3.1-3.5	3.273	0.135	0.041	11
Mazatlan	1:2.6-3.0	—	—	—	2

Comparison (* = significant at 95%)

	Mean diff.	Fisher PLSD	Scheffe F-test
San Diego vs. San Felipe	-0.134	0.106*	3.009
San Diego vs. La Paz	-0.202	0.125*	5.307*
San Felipe vs. La Paz	-0.073	0.133	0.599

longer than in the Baja California/Gulf of California specimens (ratio of this parameter to total shell length in the two measured specimens 1:2.6 and 3.0). Valves pink with more intense coloration around the anterior adductor scar.

The length-width ratios and pallial sinus ratios of the different populations are summarized in Table 1 and in Figures 66 and 67; a one-way analysis of variance (ANOVA) was run to test for significant differences in the means of the two parameters among the four morphs.

Looking at the studied material of these populations, the trend towards two main "forms" or "lineages" is obvious. A large, straight, usually quite slender, more whitish northern form lives from Santa Barbara, California, to Santo Domingo, Baja California, and is isolated from the outer coast of Baja California, in the extreme northwestern part of the Gulf of California. A smaller, generally somewhat shorter, more rosy southern form with convex ventral margin ranges from Estero de Punta Banda, Baja California, southward to La Paz and perhaps along the east

Table 2

Comparisons of the length-width ratio and the pallial sinus ratio (the ratio of the innermost point of the pallial sinus to total shell length) in *Solen rosaceus*, *S. gemmelli*, and *S. rostriformis*.

Length-width ratio					
	Ratio	Mean	SD	SE	<i>n</i>
<i>S. rosaceus</i>	4.7-5.5:1	5.126	0.233	0.054	19
<i>S. rostriformis</i>	4.6-6.0:1	5.207	0.414	0.081	26
<i>S. gemmelli</i>	5.3-6.3:1	5.714	0.355	0.118	9

Comparison (* = significant at 95%)

	Mean diff.	Fisher PLSD	Scheffe F-test
<i>S. rosaceus</i> vs. <i>S. rostriformis</i>	-0.8	0.213	0.218
<i>S. rosaceus</i> vs. <i>S. gemmelli</i>	-0.588	0.285*	8.57*
<i>S. rostriformis</i> vs. <i>S. gemmelli</i>	-0.507	0.272*	6.992*

Pallial sinus ratio

	Ratio	Mean	SD	SE	<i>n</i>
<i>S. rosaceus</i>	1:3.6-4.1	3.842	0.209	0.045	22
<i>S. rostriformis</i>	1:2.7-3.6	3.152	0.194	0.026	56
<i>S. gemmelli</i>	1:3.4-4.0	3.741	0.212	0.08	7

Comparison (* = significant at 95%)

	Mean diff.	Fisher PLSD	Scheffe F-test
<i>S. rosaceus</i> vs. <i>S. rostriformis</i>	0.691	0.1*	94.922*
<i>S. rosaceus</i> vs. <i>S. gemmelli</i>	0.101	0.172	0.683
<i>S. rostriformis</i> vs. <i>S. gemmelli</i>	-0.59	0.159*	27.255*

coast of the Gulf of California northward. According to the studied material, the two forms seem to overlap between Estero de Punta Banda (31°56'N) and Santo Domingo (28°10'N, 114°08'W) (see below).

The two allopatric populations of the northern ("San Diego" and "San Felipe") form differ slightly but significantly in their length-width ratios and less in their pallial sinus ratios (see Figures 66, 67). ANOVA (length-width ratio: $F = 13.00$; $df = 3, 47$; $P < 0.01$; pallial sinus ratio: $F = 6.32$; $df = 2, 53$; $P < 0.01$) reveals for the difference in length-width ratio of the two populations a significance at the 95% level in the Fisher PLSD test and the Scheffe F-test; the pallial sinus ratios differ significantly (95% level) only in the Fisher PLSD test.

The difference in length-width ratio between the northern "San Diego" population and the southern "La Paz" form is significant at 95% in the Fisher PLSD test and Scheffe F-test; the "La Paz" form and the northern "San Felipe" population, however, differed significantly only in the Fisher PLSD. The difference in the pallial sinus ratio is significant at 95% in the Fisher PLSD and the Scheffe F-test between the "San Diego" and the "La Paz" forms; there is no significance at all in this parameter between

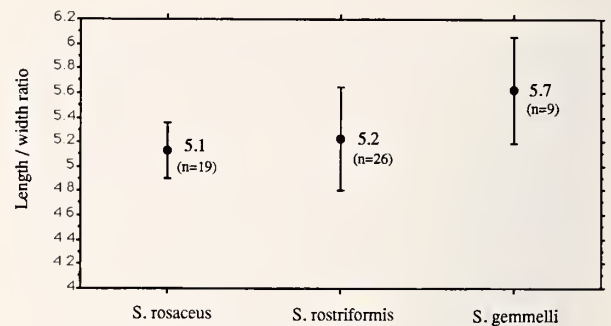


Figure 68

Length-width ratios of *Solen rosaceus*, *S. rostriformis*, and *S. gemmelli*. Bars are 1 SD.

the "La Paz" form and the "San Felipe" population. The "Mazatlan" form, with very few specimens at hand, was included in the length-width ratio analysis only; it showed a significant difference in comparison with the "San Diego" population only.

Intergrades between the different forms seem to be not infrequent: the studied specimen from Estero de Punta Banda has the outline of the southern form but is entirely white. The coloration of the specimens from Mazatlan is like that in the southern "La Paz" form, but these specimens are straight with a long distance between the pallial sinus and the posterior margin, as in the northern "San Diego" form (for the "Mazatlan" form, this parameter could not be included in the ANOVA). Specimens from Bahia Cholla (Puerto Penasco), in the northeastern part of the Gulf of California, are of the "San Felipe" form; however, they might tend slightly to the "La Paz" form (Figures 40-42).

Names are available for both forms: *Solen lappeanus* Dunker, 1871, for the large and straight northern "San Diego-Santo Domingo" variant and *Solen rostriformis* Dunker, 1862, for the shorter, slightly curved southern "La Paz" form.

The holotype of *Solen rostriformis* most closely resembles specimens from the extreme southern part of the range (La Paz): it is very faintly rosy with weak pink growth zones, and the region of and above the anterior adductor scar is more brownish pink, being most intense just behind the beaks.

The original figure of *Solen lappeanus* closely resembles the northern form and is closest to the maximum-size specimens from Santo Domingo, Baja California, with their light brownish interior and dark periostracum. The very shallow depression parallel to the anterior margin mentioned in the description and seen in the original figure is present in many specimens of this variant (e.g., Figures 51, 54). The neotype is hence selected from a lot from Santo Domingo. It corresponds also to the dimensions given for the figured specimen (72 × 11.5 mm).

The two forms are treated here as one species. Analysis

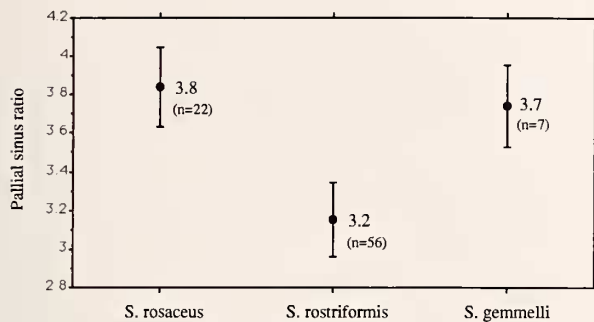


Figure 69

Pallial sinus ratio of *Solen rosaceus*, *S. rostriformis*, and *S. gemmelli*. Bars are 1 SD.

of much more material from many still unworked localities, especially on the east coast of the Gulf of California and the outer coast of Baja California (e.g., the "overlapping area" between Estero de Punta Banda and Santo Domingo), as well as an electrophoretic analysis of all populations and consideration of the fossil record could finally settle the status of these forms.

CONCLUSIONS

"*Solen rosaceus* Carpenter" as understood up to now consists in fact of an allopatric species pair, *S. rosaceus* and *S. gemmelli*, and another very variable species, *S. rostriformis*, which has an intermediate range and overlaps in its distribution with both allopatric species. Table 2 and Figures 68 and 69 compare the length-width ratios and pallial sinus ratios of these three species. The principal differences between the species pair *S. rosaceus*/*S. gemmelli* and *S. rostriformis* are the general shell form, with a usually slightly curved appearance, posterior taper, rounded anterior margin, and truncate posterior margin in *S. rosaceus*/*S. gemmelli*, in combination with a markedly shorter distance between the pallial sinus extremity and the posterior margin in the species pair. *Solen rosaceus* and *S. gemmelli* are themselves clearly distinguished by their different length-width ratios.

For the length-width ratio ($F = 9.215$; $df = 2, 82$; $P < 0.001$), the difference between *Solen gemmelli* on one side and *S. rosaceus* and *S. rostriformis* on the other side is significant at the 95% level in the Fisher PLSD test and the Scheffe F-test. In *S. rosaceus* and *S. rostriformis*, these parameters are not significantly different. In the pallial sinus ratio ($F = 107.53$; $df = 2, 82$; $P < 0.001$), however, *S. rosaceus* and *S. gemmelli* are significantly different from *S. rostriformis* (95% level), whereas there is no significant difference in this parameter between *S. rosaceus* and *S. gemmelli*.

Solen rosaceus and *S. gemmelli* probably have derived from a common ancestor that originally had a continuous distribution. A similar phenomenon is observed in the straight "lappeanus" form of *S. rostriformis*; here, however,

the differences between the "San Diego-Santo Domingo" population and the "San Felipe" population are much smaller and concern mainly the length-width ratio.

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